

CLAIMS

We claim:

- 1 1. A barrier layer for use in combination with a conductive layer, said barrier layer
2 having a particular structure comprising:
3 a) a first layer of TaN_x having a thickness ranging from greater than about 10 Å
4 to about 1,000 Å; and
5 b) a second layer of Ta overlying said first layer and having a thickness ranging
6 from about 5 Å to about 500 Å.
- 1 2. The barrier layer of Claim 1, wherein the conductive layer is copper.
- 1 3. The barrier layer of Claim 1, wherein said barrier layer is used in an interconnect
2 structure, and wherein the thickness of said TaN_x layer ranges from about 50 Å to about
3 1,000 Å and the thickness of said Ta layer ranges from about 20 Å to about 500 Å.
- 4 4. The barrier layer of Claim 1, wherein said barrier layer is used in a contact via
5 structure, and wherein the thickness of said TaN_x layer ranges from about 10 Å to about
6 300 Å and the thickness of said Ta layer ranges from about 5 Å to about 300 Å.
- 1 5. The barrier layer of Claim 2, or Claim 3, or Claim 4, wherein x ranges from about 0.1
2 to about 1.5.

1 6. A copper interconnect structure comprising the barrier layer of Claim 2 and an
2 overlying copper layer, wherein the Cu {111} crystallographic content of said overlying
3 copper layer is at least 70% of the Cu {111} crystallographic content which can be
4 obtained using a pure Ta barrier layer which is about 500 Å thick.

1 7. A copper contact via-comprising structure including the barrier layer of Claim 2 and a
2 copper fill, wherein the copper fill layer Cu {111} crystallographic content is at least
3 70% of the Cu {111} crystallographic content which can be obtained using a pure Ta
4 barrier layer which is about 250 Å thick.

1 8. A method of producing a barrier layer useful in combination with a conductive layer,
2 said method comprising the steps of:

3 a) depositing a first layer of TaN_x having a thickness ranging from greater than
4 about 10 Å to about 1,000 Å; and

5 b) depositing a second layer of Ta having a thickness ranging from about 5 Å to
6 about 500 Å.

1 9. The method of Claim 8, wherein the conductive layer is copper.

1 10. The method of Claim 8, wherein said first layer of TaN_x is deposited upon a
2 substrate having a substrate temperature ranging from about 25°C to about 500°C.

1 11. The method of Claim 8, wherein said second layer of Ta is deposited upon a
2 substrate having a substrate temperature ranging from about 25°C to about 500°C.

1 12. The method of Claim 8, wherein said barrier layer is used in an interconnect
2 structure, and wherein the thickness of said TaN_x layer ranges from about 50 Å to about
3 1,000 Å and the thickness of said Ta layer ranges from about 20 Å to about 500 Å.

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1 13. The method of Claim 8, wherein said barrier layer is used in a contact via structure,
2 and wherein the thickness of said TaN_x layer ranges from about 10 Å to about 300 Å and
3 the thickness of said Ta layer ranges from about 5 Å to about 300 Å.

1 14. The method of Claim 8, or Claim 12, or Claim 13, where x ranges from about 0.1 to
2 about 1.5.

1 15. The method of Claim 8, wherein at least a portion of said Ta layer is deposited using
2 a traditional, standard sputtering technique.

1 16. The method of Claim 12, wherein at least a portion of said Ta layer is deposited
2 using a traditional, standard sputtering technique.

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1 17. The method of Claim 8, wherein at least a portion of the TaN_x layer is deposited
2 using a traditional, standard sputtering technique.

1 18. The method of Claim 8, wherein at least a portion of said Ta layer is deposited using
2 ion-deposition sputtering.

1 19. The method of Claim 13, wherein at least a portion of said Ta layer is deposited
2 using ion-deposition sputtering.

20. The method of Claim 8, wherein at least a portion of the TaN_x layer is deposited using ion-deposition sputtering.

21. A method of producing a copper interconnect structure comprising the barrier layer of Claim 1 and an overlying copper layer, wherein the Cu {111} crystallographic content of said overlying copper layer is at least 70 % of the Cu {111} crystallographic content which can be obtained by depositing said copper layer using a pure Ta barrier layer which is about 500 Å thick, said method comprising the steps of:

a) depositing a first layer of TaN_x having a thickness ranging from greater than about 50 Å to about 1,000 Å;

b) depositing a second layer of Ta having a thickness ranging from about 5 Å to about 500 Å over the surface of said first layer of TaN_x ; and

c) depositing a third layer of copper over the surface of said second layer of Ta, wherein at least a portion of said third layer of copper is deposited using a physical vapor deposition technique, and wherein the substrate temperature at which said third layer of copper is deposited is less than about 500°C.

22. The method of Claim 21, wherein said copper interconnect structure is annealed at a temperature of less than about 500°C.

1 23. A method of producing a copper-comprising contact via structure comprising the
2 barrier layer of Claim 1 and an overlying copper layer, wherein the Cu {111}
3 crystallographic content of said overlying copper layer is at least 70% of the Cu {111}
4 crystallographic content which can be obtained by depositing said copper layer using a
5 pure Ta barrier layer which is about 300 Å thick, said method comprising the steps of:

6 *Sub* a) depositing a first layer of TaN_x having a thickness ranging from greater than
7 *Alc* about 10 Å to about 300 Å;

8 b) depositing a second layer of Ta having a thickness ranging from about 5 Å to
9 about 300 Å over the surface of said first layer of TaN_x; and

10 c) depositing a third layer of copper over the surface of said second layer of Ta,
11 wherein at least a portion of said third layer of copper is deposited using a physical vapor
12 deposition technique, and wherein the substrate temperature at which said third layer of
13 copper is deposited is less than about 500°C.

1 24. The method of Claim 23, wherein said contact-comprising structure is annealed at a
2 temperature of less than about 500°C.

1 25. The method of Claim 23, wherein said copper layer is deposited at a temperature of
2 less than about 300°C.

1 26. The method of Claim 25, wherein said structure is annealed at a temperature of less
2 than about 500°C.

1 27. A method of producing a copper-comprising contact structure including the barrier
2 layer of Claim 1 and an overlying copper layer, wherein the Cu {111} crystallographic
3 content of said overlying copper layer is at least 70% of the Cu {111} crystallographic
4 content which can be obtained by depositing said copper layer using a pure Ta barrier
5 layer which is about 300 Å thick, said method comprising the steps of:

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7 A7 a) depositing a first layer of TaN_x having a thickness ranging from greater than
8 about 10 Å to about 300 Å;

9 b) depositing a second layer of Ta having a thickness ranging from about 5 Å to
10 about 300 Å over the surface of said first layer of TaN_x ; and

11 c) depositing a third layer of copper over the surface of said second layer of Ta,
12 wherein at least a portion of said third layer of copper is deposited using a physical vapor
13 deposition technique, and wherein the substrate temperature at which said third layer of
14 copper is deposited is less than about 500°C,

15 wherein at least a portion of said first layer, or said second layer, or said third
layer, or a combination thereof, is deposited using ion-deposition sputtering.